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ABSTRACT

This is the first in a series of reports that explore the career experiences of workers with physics training. A survey conducted in 1994 examined the education and employment experiences of a large sample of members of an academic honors society for undergraduate physics students. The analysis focused on 328 holders of bachelor's degrees in physics who completed their education at the master's level. Survey findings show that these degree recipients work in all sectors of the economy, although industry and the autonomous private sector (small business, professional practices and firms, and self-employment) are the largest employers of master's degree recipients. Among employed master's degree holders with physics backgrounds, nearly three-fifths received their highest degrees in a field other than physics. Those with degrees in fields other than physics had narrower career paths than those with degrees in physics, who enjoyed a wide range of career options. Both managers and engineers strongly endorsed the beneficial effects of a physics education on their careers. An appendix discusses survey methodology. (Contains 8 figures and 23 tables.) (SLD)

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WHAT ARE MASTERS DOING?

Master's Degree Recipients with Physics Training in the Workforce: The Impact of Highest Degree Field and Employment Sector on Career Outcomes

By Donald Rosdil

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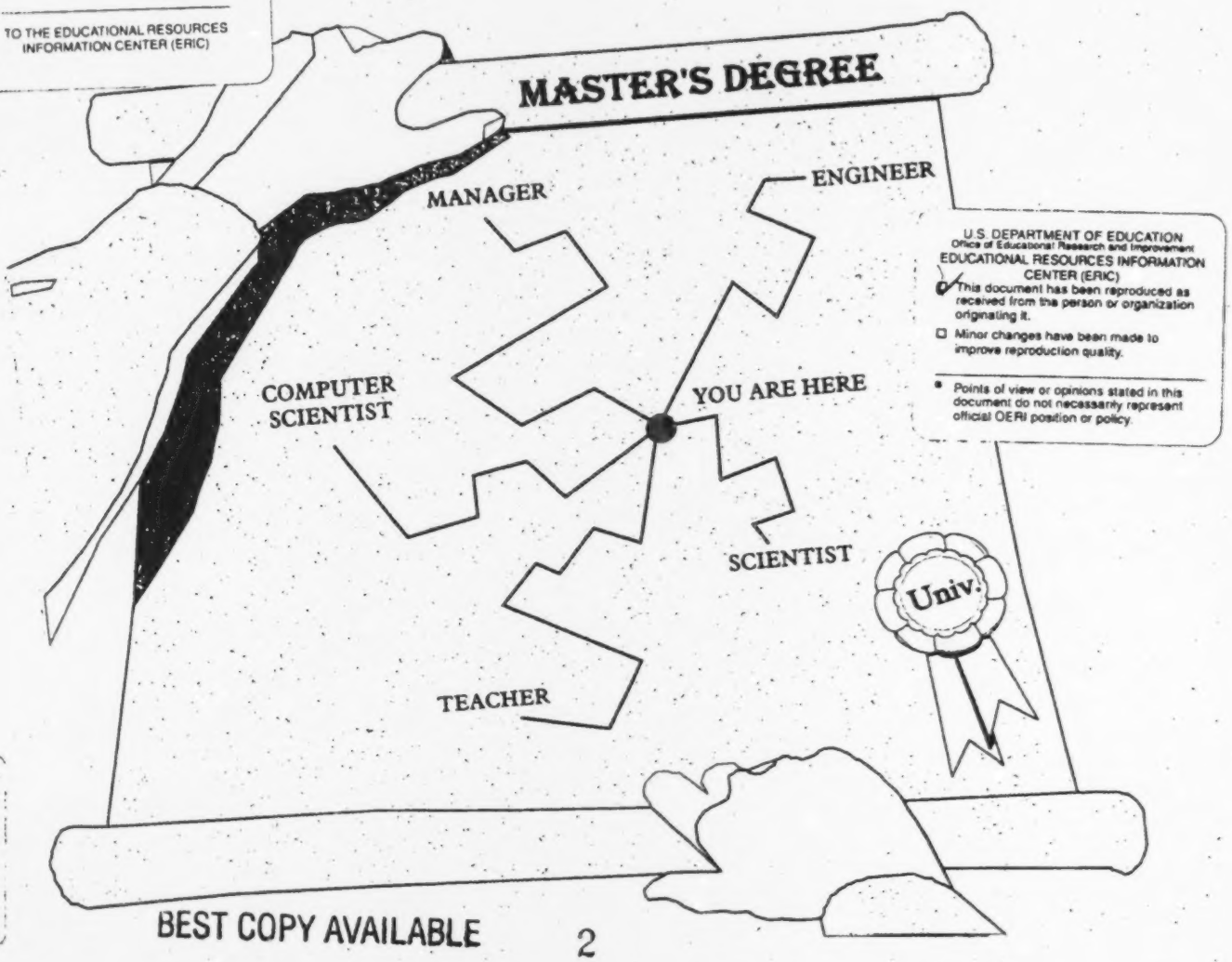

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WHAT ARE MASTERS DOING?

Master's Degree Recipients with Physics Training in the Workforce:

The Impact of Highest Degree Field and Employment Sector on Career Outcomes

by Donald Rosdil

American Institute of Physics
September 1996

Roman Czujko made a number of suggestions which greatly improved the analysis. Geneva Blake of AIP's Statistics Division played an indispensable role in this report's creation by designing the Sigma Pi Sigma study, developing the survey instrument, and supervising data collection and coding. Julius Dollison has contributed throughout this project both by performing data analyses and laying out the report. Christine Cassagnau developed the concept which became the cover design.

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Highlights

- Master's degree holders with physics backgrounds work in all sectors of the economy; however, industry, consisting of large- and medium-sized companies, and the autonomous private sector, which includes small business, professional practices or firms, and self-employment, are the two largest employers of master's degree recipients, followed by government and education **(Table 1)**.

- Among employed master's degree holders with physics backgrounds, nearly three fifths received their highest degrees in a field other than physics. The most popular specialties, after physics, were engineering, administration, computer science/mathematics, and education **(Table 6)**.

- Physics master's degree holders enjoy a wide range of career options; by comparison, those with degrees in engineering, administration, and computer science/mathematics have narrower career paths. While most of those with administration and engineering degrees are employed primarily as managers and engineers, respectively, physics degree holders are represented in a wide range of occupations, with engineer and manager the most common **(Table 9)**. Moreover, this occupational diversity persists even when we limit our analysis to those employed in industry **(Table 12)**.

- Substantial majorities of master's degree holders agree that "the undergraduate education I received in physics provided a solid background for my career." This finding was true regardless of employment sector or field of highest degree **(Tables 2, 16 & 21)**.

- Substantial majorities of master's degree holders in each employment sector report using problem solving and interpersonal skills frequently in their current positions **(Figure 2)**.

- Even within specific occupations, physics master's degree recipients experience a wider range of employment opportunities than those in other degree fields. While a large majority of managers with administration degrees work in industry (large- and medium-sized companies), those with physics degrees distribute themselves more evenly between larger firms *and* smaller firms and self-employment. In addition, a significant portion work in government. Similarly, a substantial majority of engineers with engineering degrees work in industry but almost half of engineers with physics degrees work outside industry **(Tables 14 & 19)**.

- Both managers and engineers strongly endorse the beneficial effects of a physics education on their careers. While managers with administration degrees regard analytical skills as the most important aspect of their physics training, managers with physics or engineering degrees give equal importance to analytical skills and physics knowledge in shaping their careers **(Table 18)**. As we turn from managers to engineers, we find that both engineers with physics degrees and those with engineering degrees emphasize the analytical skills gained through physics training, but the engineers with physics degrees are twice as likely as those with engineering degrees to stress the value of physics knowledge **(Table 23)**.

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Introduction

This is the first in a series of reports which explores the career experiences of workers with physics training. It will focus exclusively on those who obtained a physics degree and completed their education at the master's degree level. (This is a crucial distinction; as we will describe in greater detail in chapter II, only a minority of respondents who completed their education at the master's level did so in physics.) One of the notable omissions in research on the careers of science graduates has been the subsequent experience of master's degree recipients. Yet the presence of this group is substantial.

A recent survey conducted by AIP's Statistics Division has documented the importance of master's degrees among workers with physics training. This 1994 survey examined the education and employment experiences of a large sample of members of Sigma Pi Sigma, an academic honorary society for undergraduate physics students. In this sample and among employed physics degree holders, those who completed their educations with a master's in physics constituted 15% of the total while those who combined a physics bachelor's or master's with a master's in another field represented more than one fifth of the total. Together, these two groups who completed their educations at the master's level are 36% (N=328) of the total employed sample. Because the sample includes a large number of workers who completed their training at the master's degree level, it provides current science students with a rich source of data on common career paths at that level.

A master's degree report permits us to accomplish several objectives simultaneously. First, it will provide badly needed data on the career experiences of scientifically trained workers who complete their training at the master's degree level. Second, it allows us to examine differences in career paths between those whose highest degree is in physics and those who complete their training in other fields (engineering, administration, computer science and mathematics, education). Third, it will expose the impact of different degree combinations on the career experiences of individuals in the same occupation; our purpose is to identify the unique contribution which a physics master's can make to each of these career paths in contrast to the occupationally related degrees noted above. Finally, this report will investigate differences among master's degree holders on the basis of age. The goal is to make informed judgments about the evolution of these degree holders' employment experiences over the course of a career.

Beyond addressing specific empirical questions which concern both policymakers and those considering a scientific career, these data may also shed light on the relative importance of two kinds of explanations for employment outcomes of workers with scientific training. According to one approach, background characteristics account for differences in careers. Examples of such factors include early socialization experiences such as family background and educational training.

On the other hand, it is possible to assign responsibility for different career outcomes to workplace factors, especially the

type or function of the employer or the work environment. On this interpretation, the context in which individuals seek and obtain employment overrides many or most of the qualities which they bring to the workplace.

In reality, of course, it would be rash to give exclusive credit to one or the other set of causes. Employment outcomes will typically emerge from a complex intermingling of influences at the individual and collective levels. Indeed, the boundaries between background and workplace factors are not always as clear as we have implied. It is entirely possible, for example, that, upon reaching a critical mass in a given workplace, the proportion of employees possessing a common background characteristic such as degree level or degree field may become a collective-level attribute of the workplace. However, regardless of any remaining theoretical, conceptual, and methodological difficulties in identifying and measuring the causes of employment outcomes, this report affords us an opportunity to assess, at least on a preliminary basis, how both sets of factors influence the careers of those with physics training.

The report will include three kinds of analysis. Chapter I focuses primarily on the career effects of contextual factors, analyzing all master's degree recipients by employment sector. Chapter II looks at the role of background characteristics which the individual brings to the workplace. The emphasis here will be on the field in which the degree holder obtained the master's. Chapter III further refines the analysis of background factors by exploring the effects of highest degree field within industry. Chapter IV fills out the picture drawn by the earlier analysis by examining the variations in specific careers (manager, engineer) produced by pursuing different degree paths. We supplement our statistical findings by summarizing respondents' comments on their career experiences. Finally, the concluding section will summarize what we have learned about the employment experiences of physics degree holders and speculate about their implications for the career prospects of recent physics degree recipients.

Chapter I
The Workplace Impact on Employment Experiences

This segment of our study investigates the influence of employment sector on our respondents' employment experiences. At this point, our interest is in examining all master's degree holders with physics training without reference to their highest degree field. Later chapters of this report address the specific consequences of field of highest degree. Among employed Sigma Pi Sigma members with physics degrees in our sample, 328 completed their educations at the master's level. As **Table 1** demonstrates, about two-fifths of the total work in industry with the rest fairly evenly distributed among government, education, and the autonomous private sector (small business, professional practice, self-employment). These sectors produce quite distinctive work environments. **Figure 1** reveals that roughly 80% of workers in industry and government describe their roles as being within a group context (team member or supervisor) while those in the autonomous private sector are only slightly more likely to work in a team than independently. Finally, a three-fifths majority of those in educational

Table 1. Distribution by employment sector for master's degree recipients with a physics background [1], 1994.

	%
Industry	40
Autonomous private sector [2]	22
Government [3]	18
Education	16
Other [4]	4
Total number of respondents	328

1. Respondents currently employed whose highest degree is a master's and who have earned either a bachelor's or master's degree in physics.

2. Autonomous private sector refers to the self-employed, those in small businesses, and those in a professional practice or firm.

3. Government includes the military, national labs, and federal, state, and local agencies.

4. Other includes university medical schools, other medical/hospital services and other non-profit organizations.

Figure 1. Work environment for master's degree holders by employment sector, 1994.

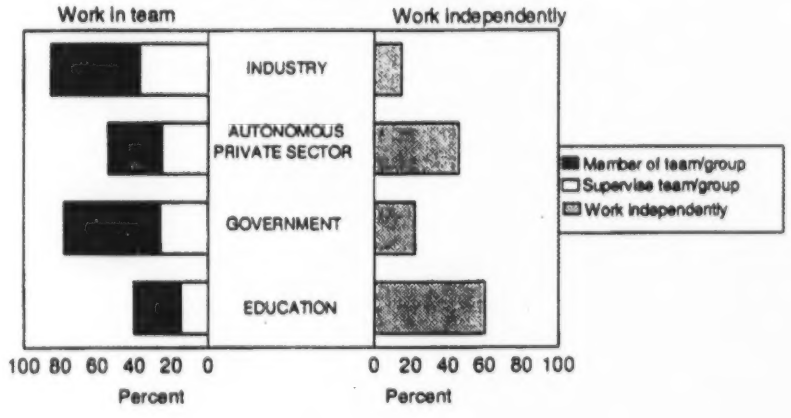


Table 2. Percent of master's degree holders agreeing with a statement about career by employment sector, 1994.	
	Physics education provided a solid background for my career*
Industry	78
Autonomous private sector	77
Government	70
Education	80

* The data reflect the percentage of respondents who chose 4 or 5 on a 5-point scale where 1 = strongly disagree and 5 = strongly agree.

institutions work independently. In **Table 2**, we make a preliminary attempt to assess the contribution of physics training to our respondents' subsequent careers. When asked their overall impressions of their careers, a large majority in each employment sector credit their physics training with giving them a solid background for their careers.

We observe in **Table 3** that the typical occupations of our respondents differ rather sharply on the basis of the employment setting. The private sector is especially interesting. A majority of respondents in both industry and the autonomous private sector work as managers or engineers. However, whereas nearly half of those working in industry have the job title of engineer, engineers are far less numerous than managers in autonomous private sector firms and only slightly more common than computer specialists. Those in government describe themselves almost equally as engineer, scientist, and manager.

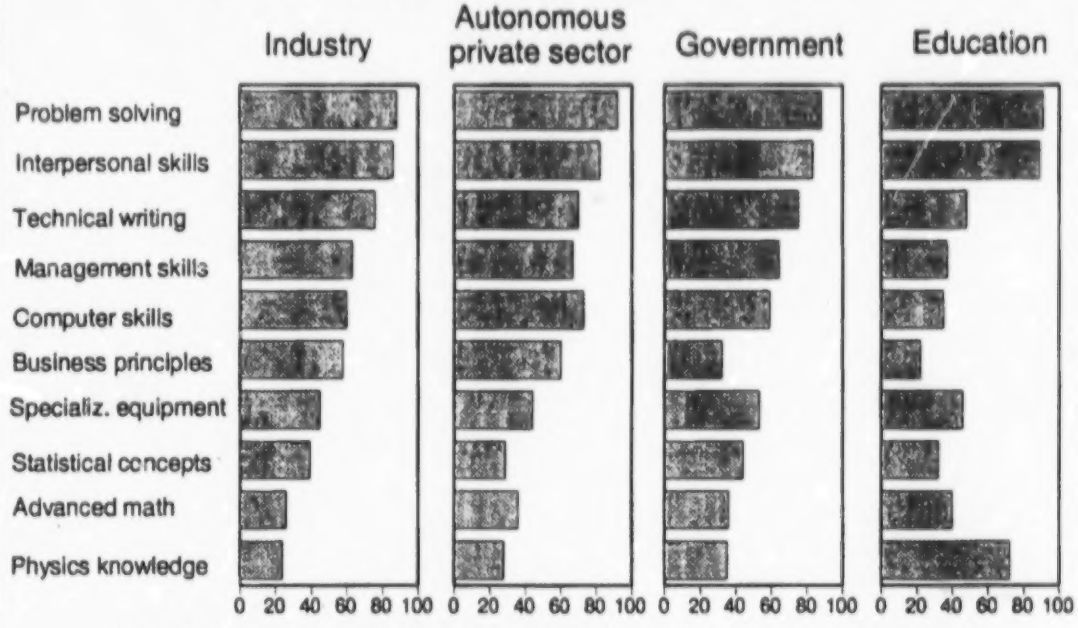
Before proceeding, a few comments on the autonomous private sector are in order. This sector is less well defined and more heterogeneous than the more familiar education, government, and industry categories. The logic behind the creation of this sector is to capture phenomena which the broader category of private sector may obscure. In particular, we hope to learn more about how self-employed consultants and small businesses which provide information-related services to clients operate within the contemporary workworld. We find, for example, that nearly one fifth of those employed in this sector are computer specialists, the largest concentration of that occupational group in any sector. Later sections of this report will shed more light on the significance of the autonomous private sector.

Another important subject which this survey investigates is the kinds of skills utilized by physics degree holders in their current

Table 3. Predominant occupations* for master's degree holders by employment sector, 1994.			
Industry	**Autonomous Private Sector**	**Government**	**Education**
Engineer	Manager	Engineer	Teacher
Manager	Engineer	Scientist	
	Computer Scientist	Manager	

* The occupations listed account for 70 percent or more of the positions mentioned by master's degree holders in each employment sector.

Figure 2. Skills used frequently in current position by master's degree holders by employment sector, 1994.



* The data reflect the percentage of respondents who chose 4 or 5 on a 5-point scale where 1 = almost never and 5 = almost always.

positions. When these degree holders are asked about the skills or knowledge they employ frequently, their responses cluster into three identifiable categories. As we observe in **Figure 2**, 80-90% of respondents across all sectors identify problem solving and interpersonal skills as crucial components of their current positions.

A second knowledge/skills category, comprising technical writing, management and advanced computer skills, and business principles, enjoys frequent use by majorities of 60-75% of respondents in industry, government, and the autonomous private sector. On the other hand, less than a third of those employed in the education sector report using management and advanced computer skills and business principles. Similarly, those in the government sector are only half as likely as those in either type of business employment to report the frequent use of business principles. These findings are intuitively clear in view of the obvious importance of management and business principles to the private sector.

Finally, distinct minorities in each sector except education claim to use statistical concepts, advanced math, or physics knowledge in their jobs. The latter finding may seem paradoxical in view of the commanding majorities in each sector who report that physics training provided a solid background for their careers. We will return to this issue in later sections of this study. Here we simply note in passing that the acquisition of problem solving

skills, which our degree holders employ extensively in their current positions, presupposes a solid foundation in physics. The one exception to the pattern just described involves master's degree recipients employed in educational organizations, nearly three quarters of whom report using physics knowledge frequently. This figure essentially coincides with the proportion of this sector whose occupation is teacher.

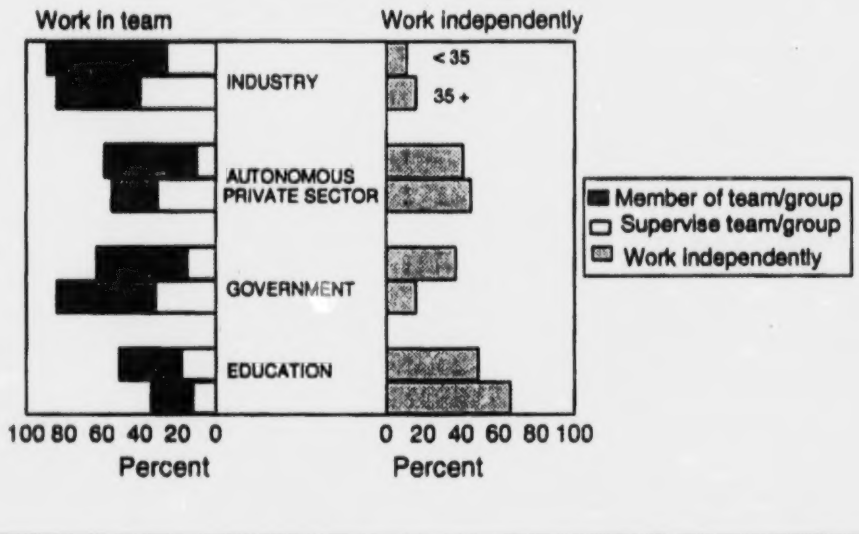
Table 4. Distribution by employment sector for master's degree holders by age, 1994.

	AGE	
	Under 35 %	35 or Older %
Industry	29	44
Autonomous private sector	19	23
Government	20	17
Education	27	12
Other	5	4
Total number of respondents	101	223

A. The Impact of Age on Careers

We next compare younger and older members of the workforce to evaluate two issues related to career evolution. On the one hand, we wish to determine how progression through the career cycle might mediate the influence of the workplace on career experience. At the same time, differences between younger and more experienced workers may reflect some of the changes that have occurred in the technical workplace during the 1980s and 1990s. While these data will not, of course, permit us to distinguish the discrete impact of each of these two processes, they will at least yield a rough estimate of their collective impact. Toward this end, we separate the sample into workers under age 35 and those 35 years old and above. We divide the sample on

Figure 3. Work environment for master's degree holders by employment sector by age, 1994.



the basis of age rather than years in workforce due to the unusual circumstances under which many workers complete their master's degrees. Since many respondents have returned to school after spending several years in the labor force, a measure of years in the workforce will not accurately capture the extent to which advanced education has influenced a respondent's career path. In addition, years in workforce is obviously inferior to age as an indicator of generational effects on the employment experience.

As **Table 4** demonstrates, the employment settings of the younger respondents are broadly dispersed with each of the four employment sectors containing at least one fifth of those surveyed. Industry is the largest, but education is only a little smaller. However, among the older respondents, industry is by far the most common employment location with 44% employed there, double the size of any other sector. Meanwhile, the proportion employed in education contracts to become just one fourth as large as the proportion in industry among the older respondents. This finding indicates that teaching at the high school level is, for many physics degree holders, a stepping stone to an eventual position in the private sector. It is also possible that today's younger workers with physics degrees are more likely to teach due to a reduced availability of private sector positions. The absence of time series data on this issue prevents us from choosing between these alternative interpretations.

We next examine the influence of age on the work environment. **Figure 3** reveals

Table 5. Predominant occupations* for master's degree holders by employment sector and age, 1994.

Under 35 years old			
Industry	**Autonomous private sector**	**Government**	**Education**
Engineer	Engineer	Engineer	Teacher
Manager	Comp-Math	Manager	Comp-Math
Comp-Math	Scientist	Comp-Math	Engineer
		Scientist	
35 years and older			
Industry	**Autonomous private sector**	**Government**	**Education**
Manager	Manager	Scientist	Teacher
Engineer	Engineer	Engineer	
	Comp-Math	Manager	

* The occupations listed account for 70 percent or more of the positions mentioned by master's degree holders in each employment sector.

that, among the younger respondents, those in industry are substantially more likely to work in a team or group setting than to work independently while those in autonomous private sector and government employment are somewhat more likely to work in a team setting than to work independently. Finally, half of those in education work independently.

By comparison with their younger fellow respondents, those aged 35 years and above were considerably more likely to work in a supervisory capacity, at least if they worked in the autonomous private sector or government. This movement to supervisory roles expressed itself through a precipitous decline in the number of older respondents working either as a member of a team in the autonomous private sector or independently in government.

Data on the occupations of our respondents divided by age confirm the growing importance of managerial activities as workers with physics training progress through their careers. **Table 5** indicates that in industry and the autonomous private sector, the proportion of managers increases in the older age group. In industry, the proportion of managers triples while in the autonomous private sector, it grows from nothing to half of the total. As a result, manager replaces engineer as the most common occupation among older workers in both employment sectors. At the same time, computer specialists decline in importance in every sector, particularly the autonomous private sector. Finally, atypical occupations in the education sector (engineer, computer specialist, scientist) sharply decrease as respondents become older, coinciding with a further expansion of the ranks of teachers. The meaning of this finding is uncertain. Perhaps high school teachers simply enjoy greater job security and superior working conditions and benefits and therefore are more prone to accumulate seniority than other professionals in the education sector. On the other hand, it could imply that younger workers with engineering and computer-related experience have more options in the labor market.

This portion of our study has revealed the decisive importance of employment sector for degree holders' career outcomes; in particular, it has demonstrated the value of dividing business employment into industry and the autonomous private sector (self-employment, small business, professional practice). Although industry is the largest employer of these degree recipients, the autonomous private sector is second, ahead of government and education. Work environment illustrates the distinctiveness of the autonomous private sector. While master's degree holders in government and industry primarily work in a group or team setting, those in the autonomous private sector (as well as those in education) are at least as likely to work independently. Likewise, engineer is the most common occupation in government and industry but managers predominate in the autonomous private sector. In fact, computer specialists are almost as numerous as engineers in the autonomous private sector.

Finally, degree holders' employment sectors help determine the kinds of skills and knowledge they use frequently in their current positions. While employed degree holders in all sectors report frequent use of problem solving and interpersonal skills, other skills exhibit less frequent use and considerable variation in usage across sectors. Thus degree holders in education are much less likely to make frequent use of technical writing, management skills and advanced computer skills than those in other sectors but far more likely to use physics knowledge frequently. In addition, degree holders in both government and education are less likely to make frequent use of business principles than those in industry and the autonomous private sector.

Chapter II
The Role of Background Characteristics in Career Choices

The previous chapter argues that workplace characteristics exercise a substantial influence on career outcomes. However, it is important not to underestimate the contribution of childhood and young adult socialization, particularly the role of formal education. In order to address this factor, this chapter identifies the typical career paths of Sigma Pi Sigma physics degree recipients with differing master's degree fields. The variation in degree field within our sample of master's degree holders is remarkable. According to **Table 6**, while a plurality of the total received their highest degrees in physics, nearly three in five obtained their degrees in other fields. Engineering and administration (primarily business administration) were the next most popular choices of field. Together with physics, they accounted for four-fifths of all the degree recipients in our master's degree sample. On the other hand, **Table 7** reveals that members of our sample displayed an adventurous spirit and a wide range of interests by earning degrees in such diverse fields as library science, national security studies, philosophy, romance philology, and social work.

Table 6. Field of master's degree, 1994.

	%
Physics	42
Engineering[1]	25
Administration[2]	13
Computer Science/ Mathematics[3]	10
Education	5
Other	5
Total number of respondents	326

1. Engineering includes degrees in material science, flight science, and industrial technology.

2. Administration includes, in addition to business administration, a small number of degrees in public administration and industrial administration.

3. Computer science includes degrees in cybernetic systems, system management, and information technology management.

As **Table 8** indicates, substantial majorities of each degree category currently work in the private sector (industry and autonomous private sector), ranging from more than 80% of the administration degree recipients to three fifths of both the computer science/mathematics and physics categories. The notable exceptions are the education degree holders who primarily work in education. Moreover, among those working in business,

Table 7. Fields of other master's degrees, 1994.

Counseling	Medicine	Philosophy	Romance Philology
Geology	National Security Studies	Psychology	Social Work
Library Science	Natural Science	Public Policy	Urban Affairs

Table 8. Distribution of employment sector by master's degree field, 1994.					
	Administration %	Engineering %	Comp/Math %	Physics %	Education %
Industry	62	51	44	33	10
Autonomous private sector	22	20	16	27	3
Government / National labs	12	20	16	18	14
Education	4	7	19	17	70
Other	--	2	5	5	3
Total number of respondents	39	80	33	135	17

respondents in three of the four degree groups (once again excluding education) are more likely to work in industry than in the autonomous private sector by a nearly three to one ratio. Physics degree holders resist this trend as they only slightly prefer industry to the autonomous private sector. As we shall observe, this is a recurring pattern in our analysis. Respondents with physics master's degrees typically enjoy more career options than those with other kinds of degrees.

In **Figure 4**, we find that field of highest degree appears to have a strong effect on the

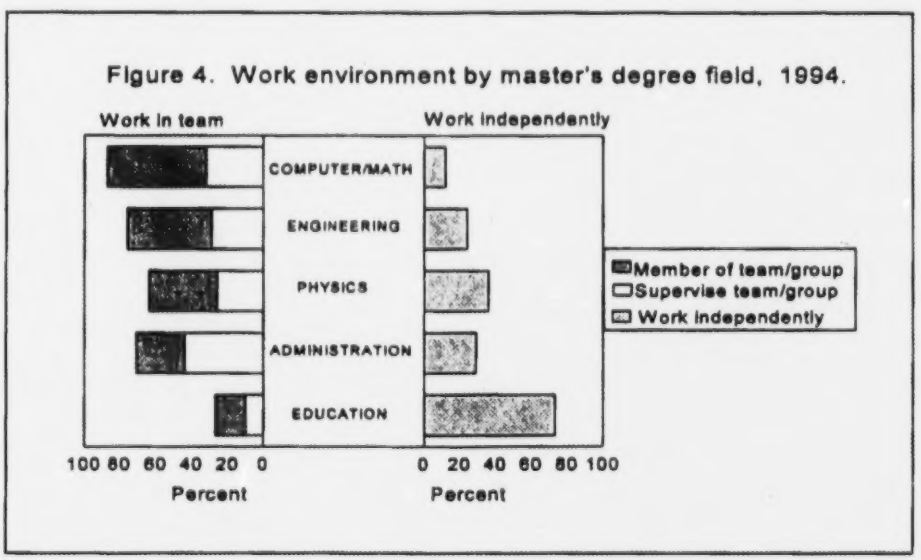


Table 9. Predominant occupations* by master's degree field, 1994.				
Administration	**Engineering**	**Comp/Math**	**Physics**	**Education**
Manager	Engineer	Comp-math	Manager	Teacher
Engineer	Manager	Engineer	Engineer	Manager
		Manager	Scientist	
		Teacher	Comp-math	

* The occupations listed account for 75 percent or more of the positions mentioned by master's degree holders in each degree field.

work environment of master's degree recipients. Respondents with computer/mathematics, engineering and physics degrees are in each case most often members of a team. On the other hand, those with administration degrees are most commonly in supervisory roles while the vast majority of education degree recipients work independently. Here the variety of careers available to physics degree holders manifests itself in their relatively equal distribution among those working independently, as a team or group member and in a supervisory role.

Table 9 demonstrates that manager and engineer are by far the most popular occupations across the various disciplines. Predictably, managers predominate among administration degree recipients while engineer dominates the occupational choices of engineering degree recipients. Similarly, more than three fourths of the education degree recipients describe their jobs as teaching while computer-related employment was the most popular occupational choice, albeit by a narrow margin, among those with computer science/mathematics degrees. Once again, the range of occupational choices available to physics master's degree holders is impressive. Each of five employment categories include at least 11% of this degree category with managers the most numerous.

As **Table 10** illustrates, perhaps the most distinctive feature of respondents identified by master's degree field is their primary work activities which correspond rather closely to the kinds of training characteristic of each degree category. Thus engineering degree recipients mention product design followed by planning at the operational level; administration degree holders choose planning at the operational level followed by planning at the organizational level; software development and product design are the predominant activities of the computer science/mathematics degree category; and education degree recipients commonly mention teaching at their foremost work activity. The most important activities of physics master's degree holders highlight once again the variety of career paths available to them. While product design followed by software development receive the most numerous mentions, each of the primary work activities for members of the other degree categories appear among physics degree holders' five most important activities.

Table 10. Predominant work activities by master's degree field, 1994*.				
Administration	**Engineering**	**Comp/Math**	**Physics**	**Education**
Operational planning	Product design	Software development	Product design	Teaching
Organizational planning	Operational planning	Product design	Software development	Providing services
Synthesizing information	Writing	Programming	Operational planning	Operational planning
Product design	Synthesizing information	Teaching	Synthesizing information	Counseling
Marketing	Organizational planning		Teaching	

* Most often mentioned by respondents among top three; each activity mentioned by at least 15 percent of respondents.

According to **Table 11**, members of all degree groups express satisfaction with the contribution of their educations to their career outcomes. Three-fifths or more of each category assert that they would get a degree in the same field if given a chance to do it over.

Table 11. Percent agreeing with statement about career by master's degree field, 1994.	
Field of degree	**If I had a chance to do it over again, I would get a degree in the same field %**
Engineering	61
Administration	59
Computer/ Mathematics	38
Physics	70
Education	77

The chief exceptions are the computer science/mathematics degree holders, only 38% of whom would get a degree in the same field.

Overall, this portion of our analysis has produced two important findings. The first is the discovery that, after earning a physics degree, students who obtain a master's in another field are effectively choosing their employment sectors, occupations, and primary work activities. In contrast, those who obtain a physics master's degree may pursue diverse occupational paths. These results are sufficiently dramatic that they deserve additional comment.

There are two ways of interpreting the first finding. One major advantage of educational specialization is that those with a physics bachelor's or master's degree who then obtain a master's in engineering, administration, or education can pursue a narrowly defined career path with some assurance of reaching

their final destinations. In each case, obtaining the nonphysics degree generally guides the student to a career which draws upon the body of knowledge defined by the master's degree field. Thus the respondents obtaining engineering degrees usually become engineers; administration degrees lead to careers in management; and education degrees direct their recipients to teaching. At the same time, those choosing one of these paths must resign themselves to a more limited menu of career options.

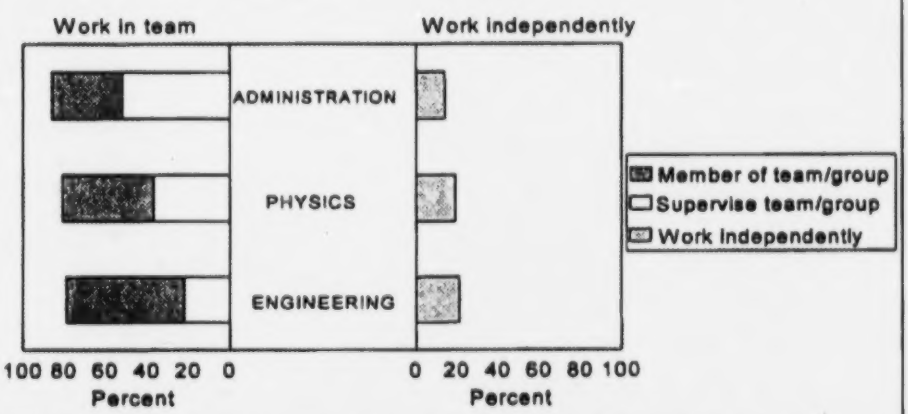
By comparison, those whose ultimate degree is a physics master's lack a clear occupational destination; they may find themselves working as managers, engineers, computer specialists or teachers depending on the effects of unspecified personal characteristics, life experiences, and career influences. How we evaluate this career indeterminacy depends greatly on how much we believe physics degree recipients value a range of employment possibilities. A major benefit of the physics master's is that those who are uncertain about their career preferences have the freedom to develop their potential in a number of directions. On the other hand, this freedom can become problematic for those who have fairly well defined objectives: what, they may ask, are the unique benefits which justify pursuing the physics master's degree? If one can attain the same career goals with greater assurance by studying engineering, administration or computer science, perhaps the best advice to aspiring, undergraduate physics students is simply to abandon the field after the bachelor's degree in favor of a more occupationally relevant, advanced degree. Thus a major objective of the final portion of our analysis will be to assess the impact of physics training within particular occupations. To reach some tentative conclusions regarding the specific benefits of a physics master's degree, we devote the final portion of our analysis to comparing individuals who enter the same occupations by different educational trajectories. Before undertaking this task, however, we will briefly explore the significance of highest degree field within the largest employment sector.

Chapter III
The Impact of Educational Background on Career Outcomes in Industry

Industry, defined as large- and medium-sized companies, is the dominant employer of individuals with a physics background and a master's degree (40% of the total). This chapter identifies the common career paths of those employed in industry from the perspective of the field of their master's degrees. We exclude autonomous private sector activities (small business, self-employed, professional practice) from this analysis due to their distinctive features. A future report based on this survey will profile this sector in considerable detail. Due to the limited number of computer/mathematics and education degrees in the sample, the analysis will include only Sigma Pi Sigma members with master's degrees in administration, physics and engineering. There are dramatic differences among these fields in their work environments. **Figure 5** reveals that a majority of respondents with administration degrees work in a supervisory capacity while a majority of those with engineering degrees work as members of a team. Physics degree holders occupy an intermediate status with slightly more reporting that they work as a member of a team than supervising.

The occupational choices of these degree holders in industry follows a pattern very similar to that for their work environment. **Table 12** indicates that whereas a large majority of industrial respondents with administration degrees work as managers, a comparable proportion of engineering degree holders work as engineers. Those with physics degrees again occupy an intermediate position with roughly equal numbers employed as managers and engineers. In addition, they are the only degree category in which a significant number work in other occupations (computer specialists, scientists).

Figure 5. Work environment in industry* by master's degree field**, 1994.



* Data in this figure and subsequent tables refer to industry and omit autonomous private sector workers (small business, professional practice and self-employed).

** Insufficient number of cases prevented analysis of workers with computer science/ mathematics or education degrees.

Table 12. Predominant occupations* in industry by master's degree field, 1994.		
Administration	**Physics**	**Engineering**
Manager	Engineer	Engineer
Engineer	Manager	Manager
	Scientist	
	Computer-Math	

* The occupations listed account for 90 percent or more of the positions mentioned by master's degree holders in each degree field.

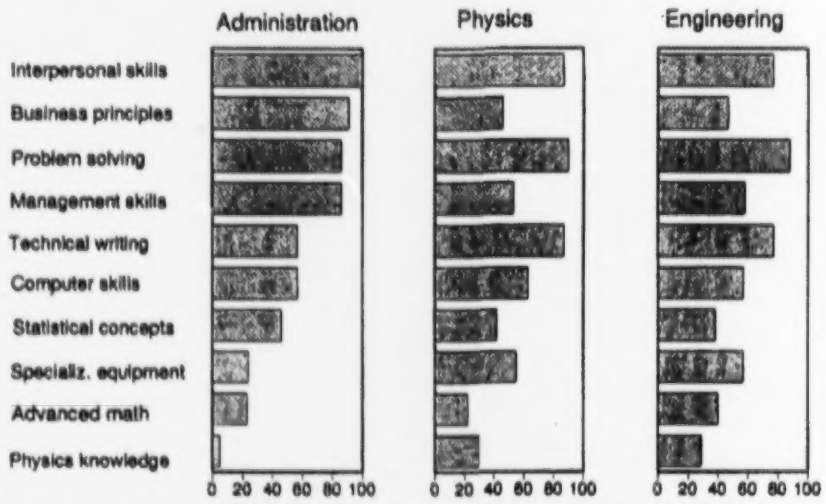
The work activities of these degree categories present a somewhat different pattern. As **Table 13** illustrates, the predominant activities of physics degree recipients (product design and operational planning) are identical to those of engineering degree holders. On the other hand, among those with administration degrees, operational planning and synthesizing information replace product design as the primary activities, followed by organizational planning.

As a final test of the impact of highest degree field on employment experience, we examine the proportions of each degree category which report using various skills and forms of knowledge frequently in their current positions. According to **Figure 6**, respondents in industry with administration degrees exhibit a different pattern of skills utilization from those with physics and with engineering degrees. Among the former, interpersonal skills, business principles, problem solving and management skills are widely employed while technical writing, advanced computer skills, and statistical concepts experience moderate levels of use. However, the physics and engineering degree holders in industry are far less likely to make use of business principles and management skills. On the other hand, respondents in both degree categories make far more use of technical writing than administration degree recipients do. Finally, those with administration degrees rarely use

Table 13. Predominant work activities in industry* by master's degree field, 1994.		
Administration	**Physics**	**Engineering**
Operational planning	Product design	Product design
Synthesize information	Operational planning	Operational planning
Organizational planning		Synthesize information
Product design		

* Most often mentioned by respondents among top three; each activity mentioned by at least 25 percent of respondents.

Figure 6. Skills used frequently in current position in industry by master's degree field, 1994.



The data reflect the percentage of respondents who chose 4 or 5 on a 5-point scale where 1 = almost never and 5 = almost always.

specialized equipment, advanced mathematics, and physics knowledge in their current positions. By comparison, respondents with physics or engineering degrees are more than twice as likely to use specialized equipment.

Thus even within a single employment sector, field of degree has substantial effects on career outcomes. With respect to primary work activities and skills frequently used, physics and engineering degree holders in industry closely resemble each other while differing in important respects from those with administration degrees. The former stress the importance of product design and planning activities while the latter concentrate almost exclusively on planning. A similar pattern arises when we examine the skills used frequently in the respondents' current positions. While administration degree holders in industry are far more likely than those with physics or engineering degrees to use business principles and management skills, the latter employ technical writing, physics knowledge, and specialized equipment more extensively.

In other areas such as their work environment and occupational choices, physics degree recipients enjoy a unique array of options not available to those with administration or engineering degrees. While a majority of administration degree holders supervise and a majority of engineering degree holders work in a group or team, those with physics degrees are equally likely to do either. Similarly, a substantial majority of administration and engineering degree recipients in industry are managers and engineers, respectively, but those with physics degrees are equally likely to be managers or engineers. In addition (and unlike administration or engineering degree holders), one fourth of those with physics degrees pursue other occupations (computer specialist, scientist).

Chapter IV
The Effect of Highest Degree Field on Workplace Outcomes Within Specific Occupations

A final objective of this report is to determine the impact of field of master's degree on the career experiences of individuals sharing a common occupation. The goal is to ascertain the independent effects of a physics degree on the quality of degree recipients' subsequent careers. Occupations are undoubtedly shaped in not so subtle ways by the employment setting. Likewise, occupations may evolve in different directions according to the mixture of skills and educational experiences which workers bring to them. For our present purposes, whether there is greater variation among workplaces in the nature of a particular occupation or between occupations under the same employer need not concern us. Likewise, we need not inquire how much workers stamp the occupation with their own character and personality and how much an occupation confronts the worker as an essential challenge from the environment. The important point is that occupations are some part of the context in which workers bring to bear their unique packages of educational training, skills, experiences, and goals.

By controlling for occupation, we can to some extent focus on the impact of other factors within a unique employment context. In particular, we can address the question: if one is to enter a particular occupation (e.g. engineer or administrator), are there advantages to getting a master's degree in physics rather than in another field? Performing this analysis requires us to select occupations which employ relatively large numbers of degree recipients across fields. Hence the analysis presented here is limited to the two most common occupations, manager and engineer.

A. The Role of Degree Field in Managers' Employment Outcomes

On the basis of master's degree field, managers differ substantially in their distribution by employment sector. In this section, we will confine our observations to the three largest degree categories (physics, administration and engineering). Note that regardless of their ultimate degree field, all managers have a bachelor's or master's degree in physics. As **Table 14** demonstrates, the vast majority of managers in each of these degree fields work in the private sector. However, while the physics and engineering degree holders working as managers distribute themselves fairly evenly between industry and the autonomous private sector, managers with an administration degree choose employment in industry more than three times as often as employment in the autonomous private sector.

On the other hand, the work settings of the three degree categories are remarkably uniform. As **Figure 7** makes clear, in each case roughly three fifths work in a supervisory capacity. In addition, at least one quarter of managers in each degree category report that they work independently. While it may appear paradoxical, this finding becomes understandable in light of the distinctive employment settings of these respondents. Although a majority of managers who primarily supervise *or* who work as members of a team or group are in industry, almost two thirds of those working independently are in the autonomous private or nonprofit sectors (results not shown). Managers in these employment settings oversee smaller offices than their counterparts in industry and government and typically devote far more of their time to nonsupervisory

Table 14. Employer type of managers by selected master's degree field, 1994.			
	Administration %	Physics %	Engineering %
Industry	74	42	42
Autonomous private sector	22	31	38
Government / National labs	4	16	15
Education	--	5	--
Other	--	6	5
Total number of respondents	24	35	22

responsibilities such as sales, marketing, consulting, and synthesizing or collecting information.

Turning next to managers' predominant work activities, we find a division among degree categories similar to that of employment sector. In **Table 15**, we see that planning activities dominate managers' priorities as one might expect. However, while the two most important activities of physics and engineering degree holders are operational planning followed by organizational planning, managers with administration degrees display a different pattern. These respondents identify organizational planning and synthesizing information as their first choices, followed by operational planning. In addition, managers with administration degrees report considerable involvement in marketing activities, unlike those with physics or engineering degrees.

Figure 7. Work environment of managers by selected master's degree field, 1994.

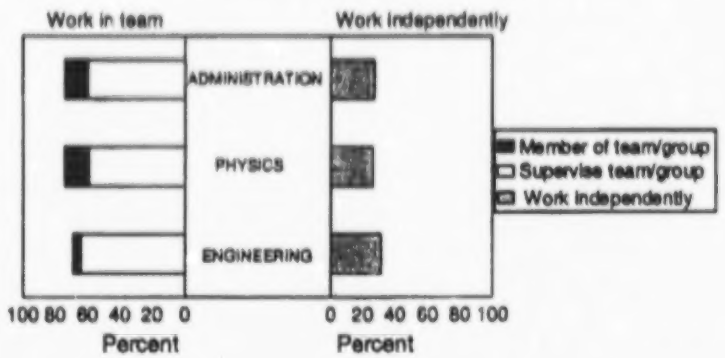


Table 15. Predominant work activities of managers by selected master's degree field, 1994.*		
Administration	**Physics**	**Engineering**
Organizational planning	Operational planning	Operational planning
Synthesize information	Organizational planning	Organizational planning
Operational planning		Product design
Marketing		

* Most often mentioned by respondents among top three; each activity mentioned by at least 25 percent of respondents.

Finally, in **Table 16**, each degree category affirms that physics provided a solid background for their careers. Most would get a degree in the same field if given a chance to do it again. The only exception are the managers with administration degrees, only a minority of whom expressed this intention.

To round out our investigation of the effect of master's degree field on the respondent's occupational experience, we also examined their answers to two open-ended opinion questions. The first dealt with what they perceived as the most rewarding aspects of their current jobs. Managers responded enthusiastically to this question; at least 90 percent of those in each degree category answered it. Moreover, in every degree category, those who responded cited on average at least 1.5 rewards. In coding their responses, we distinguished among *interpersonal*, *cognitive*, and *product or service-related rewards*. As **Table 17** makes clear, a majority of those in each degree field mentioned *product/service* rewards such as meeting customers' expectations, providing a needed service, producing high quality products, and utilizing a variety of technologies. One manager

Table 16. Percent of managers agreeing with statements about career* by selected master's degree field, 1994.			
	Administration %	**Physics** %	**Engineering** %
Physics education provided a solid background for my career	68	79	88
If I had a chance to do it over again, I would get a degree in the same field	45	69	66

* The data reflect the percentage of respondents who chose 4 or 5 on a 5-point scale where 1 = strongly disagree and 5 = strongly agree.

expressed satisfaction from "seeing new ways of doing business result in reduced costs, better quality." *Interpersonal* benefits were the second most frequent choice by managers with administration and physics degrees and the most frequent (ahead of *product/service* rewards) for those with engineering degrees. Such rewards include assisting customers, managing a team, negotiating business disputes, training/developing employees, and helping people understand concepts. One manager suggested that the essence of a rewarding workplace is "working with highly skilled and dedicated employees." *Cognitive* rewards, which include innovation, being on the cutting edge, discovering new ideas, problem solving, applying one's own ideas, and evaluating data, are the third most commonly cited by our respondents. An example of this reward, as another manager described it, is the "ability to use advanced technology/scientific concepts to solve problems."

A second opinion question asked our master's degree recipients about the most important aspects of their physics education in shaping their careers. Once again, over 90 percent of managers in each degree field answered this question. As **Table 18** illustrates, at least half of those responding in each degree field mentioned *analytical skills* such as problem solving, critical thinking, learning how to learn, problem definition, and logical thinking as important in shaping their careers. Managers were often effusive in extolling the analytical benefits of their physics training. As one expressed it, "physics education gave me the ability to break any problem/system down to its

Table 17. Most rewarding aspects of work for managers by selected master's degree field, 1994.

	Administration %	Physics %	Engineering %
Product / Service Related [1]			
Technical	5	10	11
Other product / service	45	57	47
Interpersonal			
Managerial	24	20	26
Collegial / customer	24	20	37
Cognitive	38	23	16
Other	10	7	5
Total number of respondents [2]	21	29	20

1. Table entries are percentage of those responding who cited a reward in that category; table columns do not add to 100 percent because respondents could cite more than one reward.

2. At least 90 percent of managers in each degree category answered this question.

Table 18. Most important aspects of physics education in shaping career of managers by selected master's degree field, 1994.			
	Administration %	Physics %	Engineering %
Analytical skills [1]	76	62	50
Physics knowledge	14	41	55
Other knowledge / experience	14	10	20
Initial career / employment	14	14	5
Social / psychological	14	10	5
Total number of respondents [2]	21	29	20

1. Table entries are percentage of those responding in each degree category who described that aspect of their physics education as important; table columns do not add to 100 percent because respondents could cite more than one aspect.

2. At least 90 percent of managers in each degree category answered this question.

most elementary parts--this is important in terms of understanding systems and analyzing real-time problems." The other aspect of their educations which our respondents stressed was *physics knowledge*. Although those with administration degrees seldom mentioned this factor, two-fifths of physics degree holders and a majority of engineering degree holders considered it important. Indeed, managers with engineering degrees cited *physics knowledge* slightly more often than *analytical skills*.

This portion of our analysis has uncovered both differences and continuities among managers with physics backgrounds and diverse master's degree fields. Those with administration degrees work overwhelmingly in industry and regard analytical skills as the most important aspect of their physics training by a wide margin; by comparison, managers whose ultimate degrees are in physics or engineering divide almost evenly between industry and the autonomous private sector and stress more equally the contributions of both analytical skills and physics knowledge in shaping their careers. While planning activities dominate among managers, those with physics or engineering degrees participate in operational planning more than organizational planning but administration degree holders cite organizational planning (along with synthesizing information) more often than operational planning.

At the same time, on some issues such as work environment and the claim that physics education provided a solid background for their careers, there was substantial agreement among managers with different master's degree fields. Likewise, with little variation among degree categories, managers identified product/service and interpersonal rewards as the primary benefits of their current jobs.

B. The Role of Degree Field in Engineers' Employment Outcomes

By comparison with managers, there are relatively modest differences among engineers on the basis of degree field. In this section, we compare the employment experiences

Table 19. Employer type of engineers by selected master's degree field, 1994.		
	Physics %	Engineering %
Industry	54	70
Autonomous private sector	22	15
Government / National labs	21	14
Education	3	1
Other	--	--
Total number of respondents	32	41

Table 20. Predominant work activities of engineers by selected master's degree field, 1994.	
Physics	**Engineering**
Product design	Product design
Short range research	Operational planning
Software development	Synthesize information
Process data	Writing

* Most often mentioned by respondents among top three; each activity mentioned by at least 20 percent of respondents.

of engineers whose highest degrees are in physics and in engineering, respectively. With respect to employment sector, as **Table 19** explains, a majority in both degree fields are concentrated in industry, but engineers with engineering degrees are especially likely to work there. **Figure 8** reveals that the work environments of engineers in these two degree categories also diverge somewhat. Once again, although a majority of each report working as members of a team, engineering degree recipients do so more often than those with physics degrees.

Figure 8. Work environment of engineers by selected master's degree field, 1994.

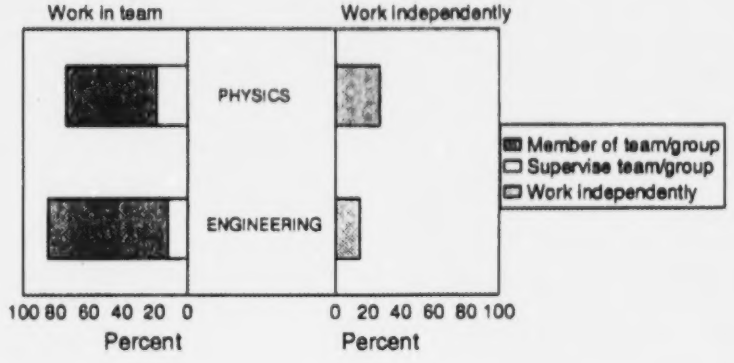


Table 21. Percent of engineers agreeing with statements about career* by selected master's degree field, 1994.		
	Physics %	Engineering %
Physics education provided a solid background for my career	87	83
If I had a chance to do it over again, I would get a degree in the same field	74	62

* The data reflect the percentage of respondents who chose 4 or 5 on a 5-point scale where 1 = strongly disagree and 5 = strongly agree.

Table 20 shows that, regardless of degree field, engineers were most likely to mention product design as their primary work activity. However, while those with engineering degrees mentioned operational planning or synthesizing information as their second choice, those with physics degrees stressed short range research, software development and processing data equally as their next most important activities. In **Table 21**, we find both degree

Table 22. Most rewarding aspects of work for engineers by selected master's degree field, 1994.		
	Physics %	Engineering %
Product / Service Related [1]		
Technical	29	15
Other product / service	42	57
Cognitive	46	41
Interpersonal		
Managerial	13	3
Collegial / customer	25	15
Other	--	8
Total number of respondents [2]	24	39

1. Table entries are percentage of those responding who cited a reward in that category; table columns do not add to 100 percent because respondents could cite more than one reward.

2. At least 85 percent of engineers in each degree category answered this question.

groups expressing broad satisfaction with the results of their education. Large majorities claimed that their physics education provided a solid background for their careers and expressed a willingness to get a degree in the same field if they had to do it over.

According to **Table 22**, large majorities of engineers in both degree categories described the satisfaction of seeing their efforts yield a successful *product or service* as among the most important rewards in their current positions. One engineer mentioned his pleasure in "completing a project successfully, particularly where I've overcome obstacles to do it." Another gained satisfaction simply from "seeing the impact of my decisions and recommendations on the organization." However, unlike managers, engineers made *cognitive* rewards their second choice, followed by *interpersonal* ones. In addition, physics degree holders were twice as likely to identify an *interpersonal* reward in their current position as those with engineering degrees.

Engineers' reports on the most important aspects of their physics educations produced the only substantive differences among master's degree fields. As **Table 23** illustrates, physics degree holders preferred *physics knowledge* over *analytical skills* as most important in shaping their careers, but engineering degree holders chose *analytical skills* over *physics knowledge* by a two-to-one margin. Another interesting finding is that *other knowledge/experience*, including "hands-on" research and laboratory experience, leadership roles, computer skills, and coursework in mathematics, statistics and engineering, loomed larger in importance for engineers than it did for managers. Indeed, engineers with engineering degrees were more likely to describe *other*

Table 23. Most important aspects of physics education in shaping career of engineers by selected master's degree field, 1994.

	Physics %	Engineering %
Physics knowledge [1]	59	32
Analytical skills	44	65
Other knowledge / experience	33	26
Initial career / employment	11	12
Social / psychological	4	9
Other	7	3
Total number of respondents [2]	27	34

1. Table entries are percentage of those responding in each degree category who described that aspect of their physics education as important; table columns do not add to 100 percent because respondents could cite more than one aspect.

2. At least 85 percent of engineers in each degree category answered this question.

knowledge/experience and initial career/employment experiences as important in their careers than they were to name *physics knowledge*.

In general, our investigation of the impact of master's degree field on engineers' employment experience has uncovered few major differences. A majority of respondents in both degree categories report working in industry and as members of a group or team although those with engineering degrees are more likely to do so. Similarly, both groups describe product design as the primary activity in their current positions and express broad satisfaction with the role of physics training as a foundation for their careers. Differences only emerge when engineers discuss the rewards from their current positions and the most important aspects of physics training in shaping their careers. Engineers whose highest degree is in physics were twice as likely to cite interpersonal rewards as those with engineering degrees. In addition (and not surprisingly), respondents with physics degrees were almost twice as likely as those with engineering degrees to rate physics knowledge as important in shaping their careers.

Chapter V
Summary and Conclusions

The first chapter of this study demonstrates the substantial influence of employment sector on career outcomes. Our first discovery was that, while three fifths of all master's degree holders with physics backgrounds work in business, an important part of that employment is in the autonomous private sector, consisting of small businesses, professional practices and self-employment. Dividing business employment into industry, consisting of large- and medium-sized businesses, and the autonomous private sector has serious implications for several aspects of respondents' employment experience, especially work environment and occupation. Although the vast majority of degree holders in industry and government work in a team setting (supervision, team/group member), those in the autonomous private sector are almost as likely to work independently as in a team. Similarly, whereas degree holders in industry are equally likely to work as managers or engineers, those in the autonomous private sector are much more likely to work as managers than as engineers; indeed, those with computer-related employment are almost as common as engineers in the autonomous private sector.

On the other hand, a background characteristic such as ultimate degree field also clearly discriminates among our master's degree sample. *Nearly three fifths of Sigma Pi Sigma members with master's degrees received their highest degrees in a field other than physics.* The most popular specialties after physics, were engineering, administration, computer science/mathematics, and education. Another key finding of this portion of the report is that, among master's degree holders with a physics background, those whose highest degree is also in physics enjoy a wider range of career options than those with degrees in administration, engineering and computer science/mathematics. For example, while a majority in each degree field work in business, only the physics degree holders are as likely to work in the autonomous private sector as in industry. Similarly, whereas most administration degree recipients work in management and most engineering degree recipients are engineers, those with physics degrees are well represented in five occupations, including computer specialist, scientist, and teacher. Moreover, this occupational diversity persists even when we limit our analysis to those employed in industry.

Even if we confine our investigation to a specific occupation, the highest degree field of job holders sometimes strongly impacts employment experience. Thus, while only two-fifths of managers with either physics or engineering degrees work in industry, three fourths of those with administration degrees do so. Likewise, although managers in every degree field describe planning activities as their most important, those with administration degrees emphasize organizational activities over operational ones but those with physics or engineering degrees stress operational activities.

While the more readily measurable characteristics of the workplace yield crucial insights on the difference which a respondent's highest degree field can make, the real contribution of a physics degree to career outcomes may be expressed in intangible terms. By asking how a physics education has shaped respondents' subsequent careers, we can gauge more effectively the true benefits of a physics degree. Our investigation reveals that, among

managers, physics knowledge and, in particular, the analytical skills which a physics education confers on its recipient have had a dramatic effect on their subsequent careers. Although managers with physics or engineering degrees gave equal importance to these two aspects, even those with administration degrees strongly endorsed the problem-solving skills gained in physics coursework. The result was similar among engineers. Both those with physics degrees and those with engineering degrees prize the analytical capacities which physics training gave them; however, engineers with physics degrees are twice as likely as those with engineering degrees to acknowledge the enduring value of physics knowledge itself in shaping their careers.

While this is hardly a definitive treatment of these issues, we hope to have demonstrated that obtaining a physics degree is far from a liability for a student's eventual career experience. To a much greater extent than either an engineering or administration degree, a physics degree gives Sigma Pi Sigma members a remarkable flexibility in designing a future career. More important, workers who obtain a physics master's report that specific knowledge and problem solving skills gained in their physics education have exercised a major influence in guiding their subsequent careers. All of this should be welcome news for anyone contemplating a higher degree in the physics field.

APPENDIX A
Survey Methodology

Sigma Pi Sigma, the undergraduate physics honor society, maintains a database of all individuals who became members since the 1920's. A sample was drawn of members who were inducted into the society as undergraduates, who had earned their bachelors degrees since 1945 and who had a valid address in the database. These restrictions left a pool of 21,000 members from which the sample was drawn. Men were sampled at a rate of 1:5, while women were sampled at a rate of 1:2 in order to ensure an adequate representation of women in the sample. The sample of 5,011 members consisted of 3676 men and 1335 women.

An 8-page questionnaire was mailed to the sample. This questionnaire included the following issues: current career status, major work activities, relevant skills used on the job, employer characteristics, importance of a physics background in one's career, and educational background. The majority of the items were forced-choice, but numerous open-ended items were also included to provide opportunities for respondents to elaborate on issues raised elsewhere in the questionnaire.

The first mailing was sent on August 4, 1994. This was followed by a second mailing to non-respondents on September 7th. The 160 postal returns and the eight members who were identified as deceased were removed from the sample, leaving 4843. Of these 1578 or 33% responded.

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